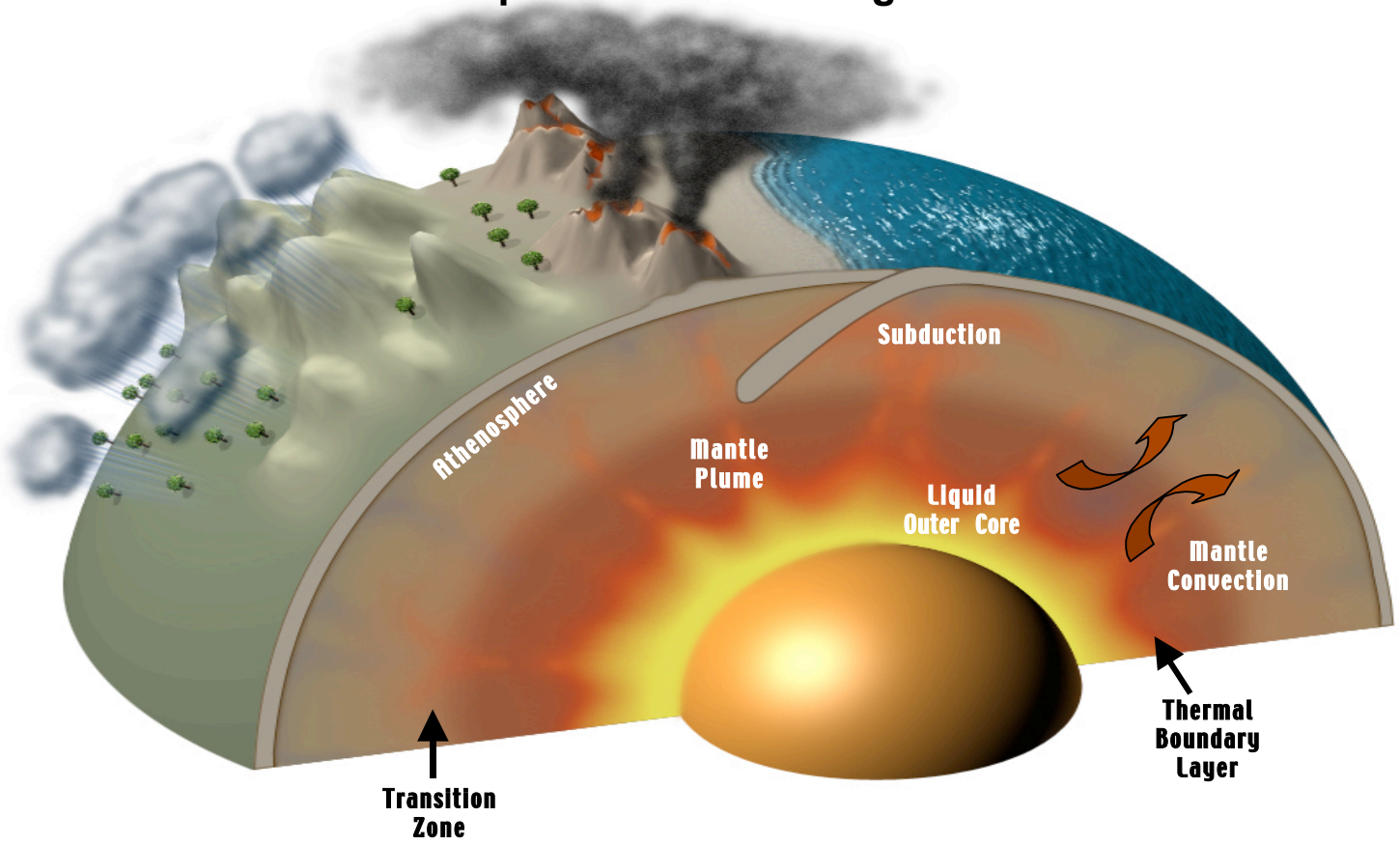
Earth's Surface and Interior Structure

The Solid Earth Science Working Group (SESWG) has mapped out a course for the future of solid earth research at NASA (http://solidearth.jpl.nasa.gov)

How is the Earth's surface being transformed and how can such information be used to predict future changes?

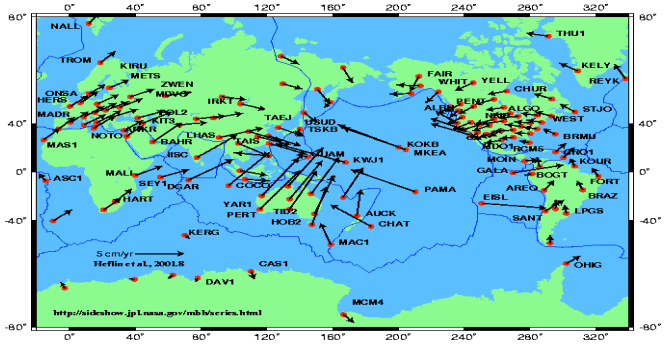


What are the motions of the Earth and the Earth's interior, and what information can be inferred about Earth's internal processes?

How is the Earth's surface being transformed and How can such information be used to predict future changes?

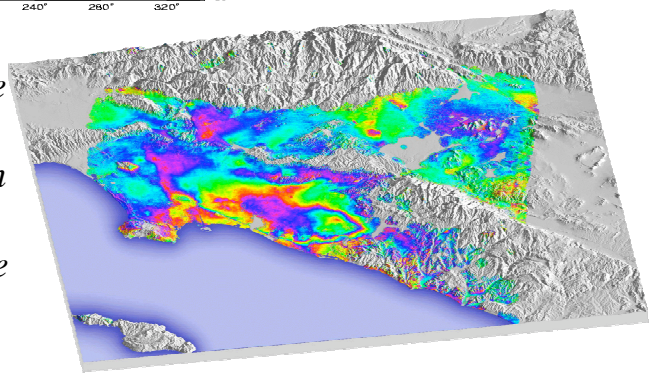
Background and Issues:

- Natural hazards such as earthquakes, volcanoes, landslides, floods, sea level rise, and wildland fires are major societal threats.
- Characterizing and understanding the underlying forces is required to move toward predictive capabilities.
- Space based geodetic and gravity measurements are revolutionizing our ability to characterize, understand and predict the changes in the Earth's surface which generate natural hazards.



Tectonic plate motions measured continuously to better than a mm/yr by the global space geodetic networks…..

drive deformation at the plate boundaries such as the L.A. Basin. InSAR and the SCIGN GPS network within the basin measure mm scale surface changes due to these tectonic forces and changes in aquifer water content.



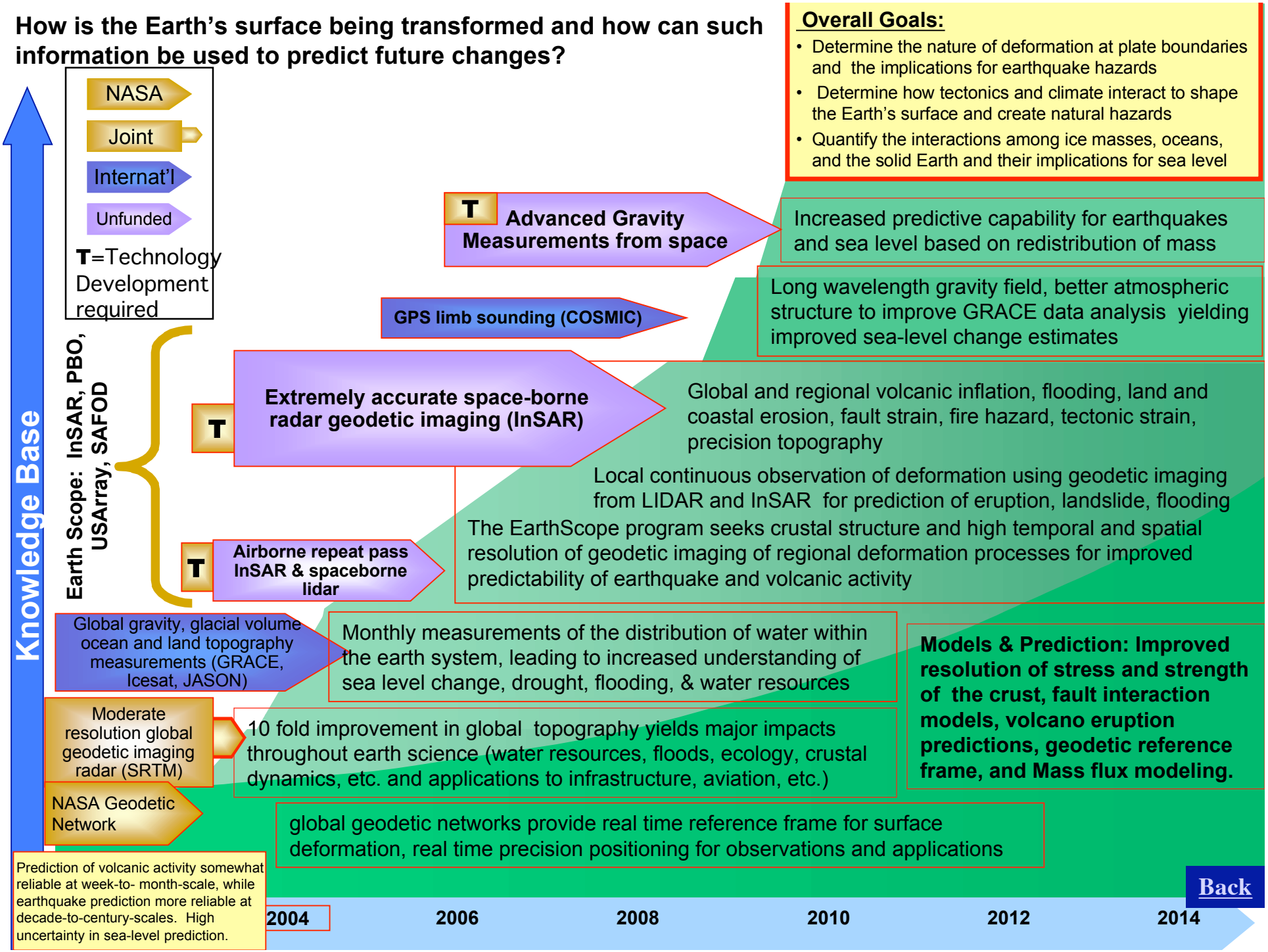
Why NASA:

NASA sponsored geodetic networks provide a stable accurate reference frame and regional fiducial measurements with mm resolution using NASA developed technology and international collaboration.

NASA developed Inteferometric Synthetic Aperture Radar (InSAR) and lidar techniques (both airborne and satellite) provide high resolution topography, surface deformation and surface cover at global and regional and local scales.

NASA provides international leadership and innovation in the development and application of these space geodetic techniques including space based gravity

Forward


How is the Earth's surface being transformed and how can such information be used to predict future changes?
Overall Goals:
• Determine the nature of deformation at plate boundaries and the implications for earthquake hazards
• Determine how tectonics and climate interact to shape the Earth's surface and create natural hazards
• Quantify the interactions among ice masses, oceans, and the solid Earth and their implications for sea level
NASA
Joint
Internat'l
Unfunded
T=Technology Development required
Knowledge Base
T
Advanced Gravity Measurements from space
Increased predictive capability for earthquakes and sea level based on redistribution of mass
GPS limb sounding (COSMIC)
Long wavelength gravity field, better atmospheric structure to improve GRACE data analysis yielding improved sea-level change estimates
Earth Scope: InSAR, PBO, USArray, SAFOD
T
Extremely accurate space-borne radar geodetic imaging (InSAR)
Global and regional volcanic inflation, flooding, land and coastal erosion, fault strain, fire hazard, tectonic strain, precision topography
Local continuous observation of deformation using geodetic imaging from LIDAR and InSAR for prediction of eruption, landslide, flooding
The EarthScope program seeks crustal structure and high temporal and spatial resolution of geodetic imaging of regional deformation processes for improved predictability of earthquake and volcanic activity
T
Airborne repeat pass InSAR & spaceborne lidar
Global gravity, glacial volume ocean and land topography measurements (GRACE, Icesat, JASON)
Monthly measurements of the distribution of water within the earth system, leading to increased understanding of sea level change, drought, flooding, & water resources
Models & Prediction: Improved resolution of stress and strength of the crust, fault interaction models, volcano eruption predictions, geodetic reference frame, and Mass flux modeling.
Moderate resolution global geodetic imaging radar (SRTM)
10 fold improvement in global topography yields major impacts throughout earth science (water resources, floods, ecology, crustal dynamics, etc. and applications to infrastructure, aviation, etc.)
NASA Geodetic Network
global geodetic networks provide real time reference frame for surface deformation, real time precision positioning for observations and applications
Prediction of volcanic activity somewhat reliable at week-to- month-scale, while earthquake prediction more reliable at decade-to-century-scales. High uncertainty in sea-level prediction.
Back
2004
2006
2008
2010
2012
2014

Progress of knowledge and understanding toward

How is the Earth's surface being transformed and how can such information be used to predict future changes? R

Forward

Knowledge Available in 2002	Knowledge Available in 2015
Space geodesy demonstrates measurement of mm scale changes in topography.	Global topography available at meter spatial resolution and decimeter vertical accuracy.
Geodetic imaging demonstrated for cm level topography and surface characteristics for fuel load, land and coastal erosion, flooding landslide hazard. Global topography from SRTM at 90m resolution in development	Continuous surface change measurement over key high risk regions at mm scale.
Periodic and aseismic centimeter scale strain events are detected, some seismic precursor events are observed in the surface deformation field.	Crustal strain, crustal stress, and crustal strength estimates combined with IT data mining to enable the forecast of earthquakes with annual or better resolution for selected regions.
Volumetric changes in volcanoes detected by InSAR reflect movement of magma at depth without seismic or eruptive manifestations of activity.	Volcanic inflation models incorporating geodetic, seismic and optical observations provide up to one year advance warning on eruptive phases for the world's active volcanoes. Global volcano pre-eruptive volcano activity is available to decision makers.
Major faults have been identified, post seismic stress changes linked to subsequent earthquake occurrence along some faults.	
Landslides can be differentiated by hydrological and seismic forcings.	
Time variable gravity due to seasonal atmospheric and hydrologic transport observed at seasonal to interannual scales.	High accuracy and high resolution measurements of time variable gravity detect ocean floor landslides and strain accumulation at ocean trenches, and regional water budgets
Sea level change estimates of 1-2 mm/yr but mechanism is uncertain and acceleration terms are uncertain.	Lithospheric loading, mass flux, and reference frame models provide sub mm/yr sealevel change accuracy.

Progress towards answering question: products

How is the Earth's surface being transformed and how can such information be used to predict future changes?

Back

Products Available in 2002	Products Available in 2015
mm scale Space Geodetic (GPS) point solutions of crustal deformation over selected volcanoes and fault zones.	3-D geodetic imaging of crustal deformation and surface change at high spatial and temporal resolution. GPS and InSAR, hyperspectral imaging supported by lidar mapping in selected
Two decades of global geodetic measurements, giving mesoscale motion of the Earth's crust at annual rates.	Directed observation of surface change with InSAR and hyperspectral imagery of selected targets for risk assessment and disaster management.
Preliminary 90 meter posting topographic maps for North America and South America. High resolution lidar mapping at 5m postings demonstrated for test sites.	High resolution global topography at meter resolution and decimeter vertical accuracy.
Terrestrial reference frame with 2 to 5 cm accuracy.	mm scale TRF accuracy and stability on decadal scales for sea level change and regional scale crustal deformation.
Near term volcanic eruption warnings for selected volcanoes, no earthquake or landslide forecasts.	Global near and long term eruption risk and alerts, landslide risk assessments for US and selected global regions, severe storm disaster risk models, preliminary earthquake forecasting for selected tectonic zones.